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Mechanical System for Preventing Wheel Lock in Automobiles

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Abstract—***According to Ministry of Road Transport and Highways total number of accidents in India in calendar year 2012 was 4,90,383. Many accidents occur due to skidding after wheels get locked. This paper is an attempt to develop a cheap and safe braking system which can provide safety at lower cost. It has been reported that ABS have sometime led greater stopping distance.***

Keywords—Braking System, Varying Brake Force, Spring Expansion, ABS, Cadence Braking

I. Introduction

First we will talk about Anti Lock Braking system that is currently sold in market. ABS works on the principle of cadence braking or pumping of brakes. Along with having many advantages ABS also has some disadvantages which are as follows-

1-It has been reported that ABS have led to greater stopping distance.
2-it is expensive to buy as well as maintain.
3-ABS are delicate.
4-It will not allow to stop fast on loose surfaces such as sand, snow, gravel etc.

The current technology for preventing locking of wheels is ABS i.e. Antilock Braking System which significantly increases control on vehicle and is costly. It works on the concept of threshold braking. The paper basically presents a new system which is based on the concept of varying brake force which increases linearly and does not apply whole of braking force at a time. Also, it applies braking force in steps as a result it never applies whole of braking force at a moment rather force is distributed over time in different amounts and is delivered in two different ways. Application of brake takes place in such a way that the vehicle could be steered throughout the braking process. It also does not allow the wheel to get locked.

It works on the principle of gradual application of braking force. The spring system used in the system will expand in direct proportion to the braking force required.

Since $F = k*X$
Also, $X = 1/ k*F$

Hence the expansion of spring will be in direct proportion to the force faced by it.Though above description just gives the basic concept, in depth description is given below.

It basically has the same components as the normal disc brake system but in addition to it has a system comprising of springs, rods, brake lines, electrical circuit which comprises of switches, pumps and an additional caliper per disc. The spring system has set of rods each of whose one end is attached to the centre of wheel and is free to move along circumference and other ends are attached to extension springs. The springs are hinged with the rods at their end. One end of the spring system is fixed with the fork and other end is attached to another caliper C1 which moves along with the spring system from position A to position B. At position B another caliper C2 is fixed. There are two switches S1 and S2 which is for caliper C1 and caliper C2 respectively. In this case C1 will move on expansion of springs and the fixed end will be at point ‘B’. The brake line attached to caliper C1 should be long enough so that it can move along with caliper C1. Two pumps will be required for each caliper to build up and release pressure as and when required.

II. Material and Methodology

Construction of the Braking System

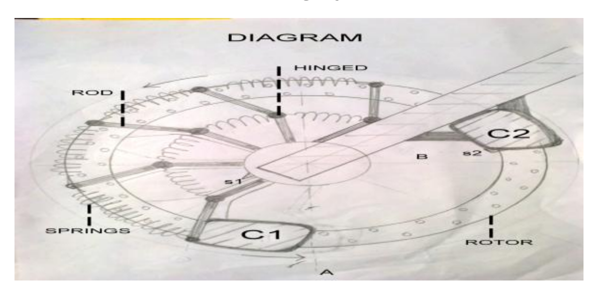


Figure-1 diagram of braking system

WORKING

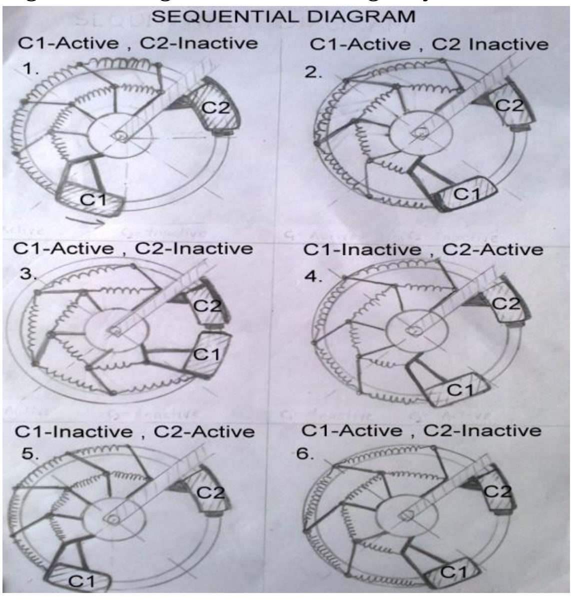


Figure 2 sequential diagram of system

Force by spring system increases linearly.

Since

F = k*X

Also, X = 1/ k*F

Hence the expansion of spring will be in direct proportion to the force faced by it.

Detailed description-

In case of emergency braking when we instantaneously pull brake lever, calipers clasp rotor .To prevent wheel from locking, caliper is attached to springs which is in turn attached to upright or the fork. Caliper makes limited movement along with disc. So caliper makes repeated motion on same path. This will prevent the disc from locking. Maximum braking force provided by the spring system is lesser than the maximum force of static friction between tyre and road, hence no chance of skidding.

Case of hard application of brake:

With the application of brakes caliper C1 clutches disc and starts moving with the disc with the whole spring system expanding and trying to pull caliper backwards. Position A to B makes 120°. As C1 reaches 'B' it press 'S2' which deactivates C1 and activates C2. As a result C1 goes back to 'A'(meanwhile C2 is active) and press 'S1' which activates C1 and deactivates C2. This repetitive process continues till the vehicle has enough momentum to turn the spring system. Thus an alternative process of static and flexible braking takes place which causes the vehicle to lose momentum and stop without making the wheel to skid.

Now we will talk about normal braking in which braking is not as hard and instant.

In this conditions wheels do not get locked rather caliper slides against the disc and kinetic friction acts against rotation of disc which causes deceleration. Locking or sliding of calipers with the wheel will depend upon the amount by which force is applied on brake pedal. What happens is that kinetic friction force pulls caliper forward but the it is hindered by the spring system which gets expanded by some amount depending upon the force on the caliper. One disadvantage is that the brake is not stiff so driver will not feel confidence on braking until he gets used to it.

This system can be used in two configurations.

1. For dry surface- In this configuration both calipers C1 and C2 will work. What happens is that braking occurs every time. First C1 travels along the disc providing deceleration and in the time when C1 comes back C2 gets activated and provides braking force.

2. For wet surfaces- In this configuration only caliper C1 works. Braking occurs only for the time in which the caliper C1 is applying force on disc and the wheel is free for the time when caliper C1 goes back to 'A'. In this C2 always remains deactivated. Thus driver gets that time as additional time to steer vehicle, though deceleration is slow in this case however driver gets better control on vehicle.

III. Results and Table

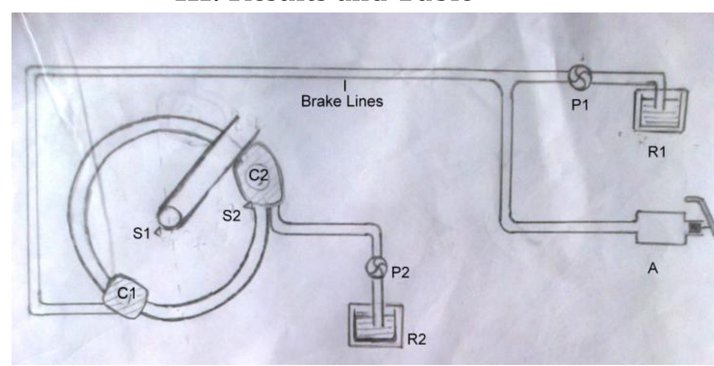


Figure-3 connection of caliper, brake lines and pumps

C1: Caliper 1(Moving Caliper)
C2: Caliper 2(Fixed Caliper)
S1: Switch 1 P1: Pump 1
S2: Switch 2 P2: Pump 2
A: Master Cylinder and Brake Pedal Assembly
R1:Reservoir 1(For P1) R2: Reservoir 2(For P2)

UNIT	ACTION / STATUS	
P1	ON	RELEASED
P2	RELEASED	ON
S1	ON	OFF
S2	OFF	ON

Table 1

Figure 3 shows arrangement of brake lines, pump, lever and brake oil reservoir and the table shows working of the system.

Calculations

According reference (i) the coefficient of friction between tyre and wet road is 0.4 and between tyre and dry road is 0.7 .

So in order to prevent skidding, the force offered by tyre should not exceed maximum force of static friction and this maximum force would be Fn (normal force on tyre × coefficient of friction). In other words this much should be the maximum force offered by the spring system i.e. the force offered on it's maximum expansion.

Calculating spring constant of springs.

For outer row of spring.

Considering a vehicle of mass 1000kg and mass distribution of 60%-40% front to rear, weight on front axle=600 kg.

So weight on each wheel=300 kg

Coefficient of friction=0.7

Hence maximum force between tyre and road without slipping = 0.7x300x9.81 N= 2060.1 N

Force on each row of springs = 2060.1 / 2 =1030.05 N

Considering a disc of 300mm diameter.

Circumference of path on which outer springs expands = πd = 3.14×0.3 = 0.94m

4 springs are considered in each row.

Initially on zero expansion

Angle covered by each row is 150° and length covered= (150/360)x0.94 = 0.39m
Now on full expansion each row will cover an angle of 150+120 = 270°.
Therefore net expansion = (120/360)x0.94 = 0.31m
Hence new length =0.39+0.31= 0.70m
Expansion in each spring = 0.31/4 = 0.077m
Therefore Δx= 0.077m and F= 1030.05 N
And k(spring constant) = F/Δx= 1030.05 / 0.077 =13377.27 N/m
Hence spring constant for outer springs is 13.377 N/mm .
This way we can find spring constant for springs of inner row and for rear wheels.
Since braking force never exceeds the value of maximum frictional force, skidding is prevented. Maximum braking force prior to skidding has been utilised to provide maximum deceleration. Since at maximum expansion braking force exceeds the maximum static frictional force in case of wet road slight skidding may take place but wheel will not get locked and driver would be able to steer since wheel does not stop to rotate.

Advantages

1. Cheaper than ABS system currently used in market.
2. Less complexity.
3. No electronics and programming involved.
4. Less jerky braking experience since on application of brakes force applied is not instantaneous but gradual due to the gradually increasing spring force.

Disadvantages

1.It's functioning is not as resolved as ABS rather it has only two strategies to work in all conditions.
2.The spring used in the braking system will lose it's stiffness over a long period of time.

IV. Conclusion

Target was to develop a cheaper braking system that would prevent wheel lock and ensure safer braking.
Considering it's low manufacturing price and simplicity it can be considered as a better option for low cost cars i.e cars under five lakhs in India.

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References

i. Jones, Edwin R (Rudy) and Childers, Richard L, Contemporary College Physics, Addison-Wesley, 1990. 2nd Ed 1993. A well-illustrated non-calculus introductory physics text.
ii. Ministry of road transport and highways,
iii. Website of CarsDirect, www.carsdirect.com
iv. Website of wikipedia, www.wikipedia.com
v. Website of how stuff works, www.howstuffworks.com
vi. Braking of Vehicles, Automobile Mechanics by Dr. N.K.Giri.
vii. Walker, Jr., James. The Physics of Braking Systems StopTech LLC. 2005.
viii. Website of Kwik Fit, www.kwik-fit.com
ix. howcarworks.com, Working of a braking system.
x. Automotive Brakes, AUTOMOTIVE MECHANICS by William H. Crouse